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THE SCIENTIFIC WORK OF WILLARD GIBBS.

The Scientific Papers of J. Willard Gibbs. In two volumes. Vol. i., Thermodynamics. Vol. ii., Dynamics, Vector Analysis, Light, &c. Vol. i., pp. xxviii+434, price 24s. net; vol. ii., pp. viii+284, price 18s. net. (London: Longmans, Green and Co., 1906.)

THESE two handsome volumes are a fitting memorial to one who carved out for himself a very remarkable niche in the temple of scientific fame. With the exception of his one published book on statistical dynamics, we have in these collected papers practically all that Willard Gibbs put into form suitable for publication. Compared with the literary output of the leaders of science of the passing generation, this is a very limited contribution if judged only in regard to quantity. But the quality and far-reaching importance of Willard Gibbs's work place it on an eminence of excellence comparatively rarely reached. This remark specially applies to his great papers on the equilibrium of heterogeneous substances, which with his other papers on thermodynamics constitute the first volume of 434 pages. All are agreed as to the supreme importance of the thermodynamic memoirs, which give to their author a unique place among those who have done most to establish and develop the principles of this fundamental part of the doctrine of energy. It is not quite the same with the papers which form the second volume, of 284 pages, although in these also the author's characteristic qualities of mind show themselves. There is always an originality of view and a logical severity of treatment which indicate that the author has well digested his material before putting it in printed form before the eye of the public. Nevertheless, even if we do not consider the contents of vol. ii. as attaining the same high average of excellence as the contents of vol. i., their comparative brevity makes good the claim that in Willard Gibbs we had a writer and thinker of very exceptional merit.

Unlike most young scientific men, Willard Gibbs was in no hurry to publish, his earliest papers dating from 1873, when he was thirty-four years of age. The second of these papers, that on thermodynamic surfaces, became speedily known to the scientific world through the pages of Maxwell's "Theory of Heat"; and Maxwell was himself the first to construct a model of the volume-entropy-energy surface. Copies of this model were distributed by Maxwell evidently with a certain amount of playful mystery, for each recipient thought that he was the happy possessor of one of (at most) three. The writer knows of six at least, and possibly there are more. We also owe to Maxwell a very clear, brief statement of the essential feature of the great papers on the equilibrium of heterogeneous substances. In spite of this, however, the immense value of these memoirs

came to be fully recognised only very gradually, in many instances after important results had been obtained independently by later investigators. In 1892 Ostwald brought out a German translation which was reviewed at the time in these columns (vol. xlv., p. 245). A French translation followed in 1899, and now at length we have these epoch-making papers reproduced so as to be accessible to everyone. In their new dress they cover about a third more pages than in their original form in the Transactions of the Connecticut Academy of Arts and Science, and the larger type and broader page impart a dignity worthy of their high position in the literature of thermodynamics.

The first volume closes with some unpublished fragments which were intended to form a supplement to the "Equilibrium of Heterogeneous Substances." Only two of a list of nine subjects are touched upon, and one cannot but have a feeling of deep regret that the distinguished author was unable to carry out his project.

The second volume contains twenty-one distinct papers and articles arranged under four headings. In a paper on the fundamental formulæ of dynamics, Gibbs suggests using $\delta\ddot{x}$, $\delta\ddot{y}$, $\delta\ddot{z}$ instead of the usual δx , δy , δz , and shows that for certain problems the modification is of advantage. The second paper is a single-page abstract from the Proceedings of the American Association for the Advancement of Science on the fundamental formula of statistical mechanics, and is of interest as showing the trend of his thinking sixteen years before the publication of his great work on the subject. Eight papers then follow on vector analysis and multiple algebra. The first of these is the reprint of the famous "not published" pamphlet which was printed for private circulation in 1881-4, and it is in reply to certain criticisms of this pamphlet that some of the succeeding papers were written, chiefly as letters to NATURE. Willard Gibbs received his first impulse towards the study of vector methods from Maxwell, who used the quaternion notation in his "Electricity and Magnetism." Not caring for the quaternion approach, for reasons which are explained fully in his controversial articles, he elaborated a notation of his own for the frequently recurring functions familiar to students of Hamilton and Tait. What gives Gibbs's method its character is, however, his "dyadic" notation for the linear vector function. Unlike Hamilton's ϕ , which has, so to speak, only one hand to grip the operand which follows, Gibbs's dyadic has two hands, with one of which it may grip forward and with the other backward, as occasion may offer. It cannot, however, grip with both at once, so that the double-handedness is only apparent. Moreover, it is only in its expanded form that the dyadic is able thus to cleek on to an operand on either side. When, as is frequently the case, the Hamiltonian function ϕ is used, the method becomes identical with that of quaternions.

A very readable paper is that on multiple algebra, which Gibbs originally delivered as his presidential address before the mathematical section of the

American Association for the Advancement of Science. Here we find expounded with rare clearness and happy illustration the essential principles of multiple algebra. We can imagine many aspiring mathematicians getting from this article a strong impulse towards the study of a subject the fundamental principles of which are at times almost intuitive, but the working out of which in detail is full of difficulties and pitfalls to trap the unwary.

Under the heading of "The Electromagnetic Theory of Light" there are five papers, all important contributions. They show the sufficiency of the electromagnetic theory to explain dispersion and double refraction, whereas the elastic solid theory of Green could not be reconciled with experimental facts. The elastic theory was, mathematically speaking, rescued from its distressed condition by Kelvin when he imagined the contractile ether; and in regard to this Gibbs points out that, although it explains many phenomena as simply as the electromagnetic theory, it fails to give a satisfactory explanation of dispersion.

Finally, there are six miscellaneous papers, partly reviews and biographical notices. The closing sentence of his notice of Clausius, in which reference is made to the great number of papers published by the eminent German, might by a slight modification be applied to himself.

"Such work as that of [Gibbs] is not measured by counting titles or pages. His true monument lies not on the shelves of libraries, but in the thoughts of men, and in the history of more than one science."

The papers have been edited with great care by Henry Andrews Bumstead and Ralph Gibbs van Name, and the former, in the biographical notice prefixed, discusses with knowledge the scientific work done by Willard Gibbs, and gives a clear-cut picture of the man himself. A portrait forms the frontispiece to vol. i. C. G. K.

TECHNOLOGY OF SOAPS AND CANDLES.

Modern Soaps, Candles, and Glycerin. By L. L. Lamborn. Pp. xx+688. (New York: D. Van Nostrand Company; London: Crosby Lockwood and Son, 1906.) Price 30s. net.

THIS is a work intended primarily for the soap manufacturer, and more especially for the American beginner in the art and craft of soap-making. The author finds, he tells us, that the industry has hitherto been indebted for its technical literature to those who can write, but have little worth telling. To remedy this state of things he, a practical man, to practical men sends forth the present volume.

On the whole the effort is a successful one, though the book has defects. Let us summarise these at the outset. Heavy both in style and in avoidrupois, and printed on glazed paper that is very trying to the eyesight, the work is by no means an attractive one to read. There is much tedious repetition, and

an unnecessary amount of technical slang is employed. For example, on p. 340 we are directed to "kill the rosin as already described, but leave the soap open on salt alone, with entire absence of strength." The book is quite "practical" enough to dispense with kettle-room jargon. Generally, it suffers from excessive verbiage; the author has a tendency to write round his subject as well as upon it.

Now let us see what there is of value in the book. The various operations of soap manufacture are fully described, about two-thirds of the available space being devoted to this branch of the subject. Two introductory chapters outline the history and principles of soap-making; then come three others, dealing respectively with the raw materials, their purification, and their chemical characters; these are followed by one describing the mechanical equipment of a soap factory, and next by the sections which discourse of the various kinds of soap and the processes involved in their production. The treatment is eminently practical, and, so far as the reviewer can judge, entirely trustworthy. Many useful tables, formulæ, and recipes are embodied in the text; a good section on essential oils and soap perfumery is interpolated; and a large number of illustrations of apparatus are included. These last are, naturally, figures of American machinery almost exclusively they constitute quite a feature of the work.

In connection with "medicated" soaps, the author is sceptical about any appreciable curative effect being rightly attributable to the medicament or disinfectant incorporated with the soap. The proportion of active ingredient is often very small, and under ordinary conditions of use the time of contact with the skin is but short, so that the scepticism is probably justified. Such curative property as the soaps may possess is, the author thinks, inherent in the detergent itself; the remedial value lies in the mechanical action of cleansing rather than in any specific bactericidal or antiseptic effect of the incorporated substance.

In the section dealing with the manufacture of candles there are two points of special interest. One of these relates to a long-standing problem of chemical technology, namely, how best to utilise the by-product oleic acid as a source of candle material. This acid forms a large proportion of ordinary fats, but, being a liquid, is not suited for the production of candles. It is possible, however, to convert the oleic acid into solid substances (elaidic acid, hydroxystearic acid), which can be so used; but until recently the expense and the smallness of the yield have prevented the satisfactory utilisation of the by-product in this way. The author outlines the latest modification of the process for transforming oleic acid into hydroxystearic acid; it is asserted that from 85 per cent. to 95 per cent. of the former can now be obtained as the solid product, instead of only 30 per cent. as previously produced. Sulphostearic acid and stearylactone are obtained by dissolving the oleic acid in petroleum and treating the solution with strong sulphuric acid; the first gives hydroxystearic acid on hydrolysis with steam; the stearylactone is re-con-